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STRUCTURAL GEOLOGY AND GEOLOGICAL HISTORY OF THE PERRINE AND NUN SULCI QUADRANGLES (Jg-2 AND Jg-5), GANYMEDE.

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Structural Geology: Grooves are the dominant structural features on Ganymede. While single grooves are found in many areas, it is somewhat more common to find them grouped together in groove sets -- groupings of grooves with common structural trends. Grooves in sets are often nearly parallel, but fan-shaped sets are also observed. Groove spacing can vary substantially from one groove set to another, but within a given set tends to be more nearly constant. Sets may intersect with one another in complex crosscutting relationships, and the central region of Jg-5 is one of the most complicated on Ganymede in this regard. Where one groove set crosscuts another, no trace of the cut groove set is generally observed within the crosscutting set. There are a few exceptions to this rule, however, as at 40°N, 314°W. The boundaries of groove sets are often marked by particularly long and deep grooves, and the boundary between light and dark terrain is commonly marked by a single groove, or by a groove set that lies in the light terrain and parallels the boundary.

It is generally believed that the grooves on Ganymede are extensional features (Smith et al., 1979a, b; Squyres, 1980; Parmentier et al., 1982). Their underlying geologic nature cannot be determined from Voyager images, however. It appears likely that they are grabens, but the images are insufficient to rule out the possibility that they are modified extension fractures or some kind of ductile necking features. The interpretation of grooves (and groove sets) as extensional features leads to interesting possible interpretations of some structural relationships. One common relationship among grooves occurs where a groove set terminates abruptly against a single groove or groove set that runs transverse to it. In such cases, it is probably not correct to infer that the terminated groove set predates the feature cutting it. Instead, extensional deformation in the truncated groove set most likely postdates the truncating feature, with the truncating feature acting as an older margin. This interpretation is similar to that generally inferred for truncating relationships among sets of rock joints on the earth.

There is some direct but limited evidence for structural shear in the map region, seen where groove sets appear to be offset by several tens of km along narrow shear zones. Compelling evidence for compression is limited, although the feature at 40°N, 314°W cited above appears to possess parallel ridges rather than grooves, and could be compressional.

Geological History: The oldest materials within the Nun Sulci and Perrine quadrangles occur within the cratered dark materials (dc) unit (McGill and Squyres, 1991), as is generally the case for all of Ganymede. This is the most widespread of the dark units mapped in these two quadrangles. Crater densities within cratered dark materials are consistent with an age on the order of several billions of years (Smith et al., 1979a), and thus cratered dark terrain probably represents crust that has survived from the end of the primordial intense bombardment phase of solar-system history. The second most widespread dark unit is grooved dark materials (dg). Within the Nun Sulci and Perrine quadrangles it is not clear if any of the grooves that define this unit are older than light materials. Many grooves clearly pass from grooved light materials into

grooved dark materials, and there are no unequivocal truncation relationships suggesting that the grooves in the dark terrains are older than similar-appearing grooves in abutting grooved light materials. Consequently, it is possible that grooved dark materials were originally the same as cratered dark materials. The present difference in appearance and the apparently smaller density of superposed craters would thus be due to structural modification at the time of global groove formation.

After formation and cratering of the old crust now represented by the dark materials this crust was fractured and dismembered, with widespread emplacement of light materials between or on top of the surviving crustal fragments. The process of emplacement is inferred to be extrusion of relatively ice-rich magmas. The resulting light materials were subsequently extensively faulted, resulting in the intricate pattern of grooves which characterizes much of the light terrain in these quadrangles. Complex cross-cutting and truncation relationships indicate that faulting and groove formation occurred over a protracted time period, and that it almost certainly overlapped in time with the extrusion of ice-rich magmas. Furthermore, in some places clear truncation relationships indicate that smooth light materials are younger than the grooves in adjacent grooved light and dark terrains, indicating that ice volcanism continued after local cessation of groove formation.

Impact structures were forming throughout the history recorded by the light and dark materials. Basins and degraded large craters (C_1) are superposed on cratered dark materials but not on grooved dark materials or on light materials. As discussed above, they may once have existed on grooved dark materials and subsequently been rendered unrecognizable on the available images by younger grooving. It is not likely that C_1 craters and basins ever existed on any of the light units. Well preserved craters without bright ejecta (C_2) are the most abundant class of craters. Some of these are clearly older than light materials, but most are probably younger than all light units except possibly smooth light materials. Bright ray craters (C_3) appear to be younger than all light and dark units.

Two palimpsests occur in the Nun Sulci quadrangle. One of these ($356^{\circ}\text{W } 29^{\circ}\text{N}$) is very ancient, and probably is the oldest impact structure in this area. The second palimpsest ($335^{\circ}\text{W } 30^{\circ}\text{N}$) is something of an anomaly because it is superposed on light materials and is thus much younger than most palimpsests found on Ganymede (Thomas and Squyres, 1990). The change from the formation of palimpsests to the formation of lunar-like multi-ringed basins probably reflected a change in the rheology of Ganymede's crust and lithosphere (Passey and Shoemaker, 1982). If so, the existence of a relatively young palimpsest on light terrain implies two periods of rheology transition; an early one for crust with low-albedo surfaces, and a much later one for crust with high-albedo surfaces.

This brief geological history is almost certainly greatly oversimplified as a result of the poor resolution and unfavorable viewing geometry of most the images covering this area. Textural features that are just at the resolution limit of the best images suggest that a much more complex and more interesting history can be inferred when better images are returned by some future mission.

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